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relatively greater than the change in temperature. We have here, then, the principle upon which climatology should be worked out. Given a plant whose pedigree and habits of growth are well known, and a daily range in temperature from 65 to 70 degrees, what range of moisture in the soil can the plant stand? what relative humidity? wind velocity? and what intensity of sunshine? With a certain amount of sunshine, what temperature, humidity, moisture and wind velocity are necessary to maintain the favorable conditions of growth? This is climatology, and there is no reason why the approximate relation of these elements should not be worked out for different classes of plants and for different periods of their growth. The florist knows how to control these conditions to produce the development he desires or to mature the plant at any time. He does this by watching the plant itself, using the thermometer merely as an indicator of the changes he makes in the temperature. It is intuition on his part which he can not explain. It is a matter of experience and observation which he can not impart to others. If the meteorologist should observe and record these changes by his instrument as the florist is observing and controlling the development of his plants it should be possible to express the relation of the climate in language which could be imparted to others. This applies also to field culture.

One encouraging thing in this conception of climate is the fact that through cultivation we may very materially control the water supply of the soil. As this is an essential element of climate, we have then the power of modifying the climate of any locality to a considerable extent.

As the relation shown in the above equation is between certain functions rather than between the values as expressed in our ordinary meteorological tables, the equation

should be written in still more general terms. Furthermore, the conditions favorable for one class of plants are not favorable for others, and the conditions favorable for the growing period of many of our crops are not favorable for the ripening period. The general equation should then be written as follows, the Greek letters standing for certain functions of the elements of which we do not as yet know the values :

$$(1) \quad \psi(s) \left(\frac{\phi(t)}{\Gamma(h)} \frac{\theta(v)}{\Delta(w)} \right) = k$$

$$(2) \quad \psi'(s) \left(\frac{\phi'(t)}{\Gamma'(h)} \frac{\theta'(v)}{\Delta'(w)} \right) = k'$$

where s = intensity of sunshine ; t = temperature ; v = velocity of the wind ; h = relative humidity ; w = soil moisture ; and k = the constant conditions favorable for plant growth. Equation (1) may represent the conditions favorable for the vegetative or growing period and equation (2) the conditions favorable for the ripening or fruiting period. The values for some of the elements may be the same in both equations or they may all be different.

Climatology is thus shown to be the relation between the meteorological elements as measured by the development of the plant.

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THE AGE OF THE ARTIFACT-BEARING SAND AT TRENTON.

ON three different occasions during the past summer I examined the deposits on the Lalor farm at Trenton, in which numerous artifacts have been found. So far as my observation goes, nothing was seen to prove that they were not *in situ*. In all cases noted they were found with longer diameters horizontal, *i. e.*, in the position they would naturally occur if their age is the same as that of the sand in which they are found. No positive evidence was noted that the sand had been so disturbed that they might have been intruded from above.

On the other hand, they all occur within less than four feet of the surface, in the zone in which the sand may repeatedly have been disturbed by up-rooting of trees, burrowing animals and Indian burials. Nothing of structure was seen in the sand itself by which this crucial question could be positively determined. The 'red clay films' observed at various intervals in the sand are not, in my opinion, lines of stratification at all, nor are they strongly clayey. They are rather zones or bands of infiltration and deposition of ferric oxide which has somewhat cemented the sand grains. Since they are not lines of stratification, the fact that they are continuous above the specimens is not necessarily conclusive proof that the latter are *in situ*. Nevertheless, in spite of the absence of decisive evidence pro or con, I am inclined to the view that the artifacts are *in situ* and not intrusive.

The deposit in which they occur is, in my opinion, dune-sand, accumulated after the river had partially or completely excavated its trench below the level of the Trenton terrace. The reasons for this conclusion in brief are as follows :

1. *The location.* The trenches are all within 100 or 150 feet of the edge of the terrace, which here overlooks a broad sandy flood plain. According to the testimony of those who have explored most thoroughly, the artifacts are found most abundantly in the sand near the edge of the bluff. The location is one peculiarly favorable for the accumulation of wind-blown sand driven by southerly and westerly winds and derived from the steep face of the terrace before it was covered by vegetation. As the river eroded its channel below the terrace level and left bare the freshly cut bank of sand and gravel, the prevailing winds undoubtedly swept sand on to the terrace. Naturally, some would accumulate along the edge of the bluff. I have observed

wind-blown sand at many points in exactly similar positions farther north along the Delaware.

2. *The topography.* In the immediate vicinity of the trenches the surface of the terrace is slightly irregular, being diversified by low swells and saucer-like depressions. The surfaces of the swells are more sandy than of those parts of the terrace where the undulations are not present. Occasional large boulders occur on the surface of the terrace, but none were noted on the sandy knolls. Certainly none occur in the immediate vicinity of the trenches. In saying that the surrounding topography is at least *suggestive* of wind action I am not overstating the facts. In this connection, too, it should be noted that the present flood-plain is marked by low dunes now in the process of formation, and the similarity of surface is thus clearly brought out.

3. *The deposit.* Beneath the layer of forest loam, measuring six to ten inches in thickness, there is loose yellowish sand absolutely without structure lines, but traversed by two or three more or less distinct films, which, as noted above, are probably due to infiltration of ferric oxide. Beneath the yellowish sand, which has a maximum thickness of less than three feet, there is a reddish layer of sand, eight or ten inches thick, grading downward into the cross-bedded sand and gravel, which all are agreed is of glacial age and in which the artifacts are not found. In the artifact-bearing sands there is no evidence that it was water-deposited. That it is a local deposit is shown by the fact that it does not occur on the gravel seen in large open pits a few hundred yards distant from the trenches. It seems to be best developed along the edge of the terrace. Its texture is not unlike that of wind-blown sand observed elsewhere, and it is decidedly unlike the sand-beds exposed in the gravel pits. This latter fact, however, does not neces-

sarily separate it from the glacial deposited beds, although it points to such a separation.

If it is wind-blown sand, then the reddish layer between it and the cross-bedded sand and gravel probably represents the upper surface of the Trenton gravel and was the terrace surface during the interval between the accumulation of the glacial gravel and the wind-blown sand. This layer was examined very carefully in the hope of finding proof of its being an old soil. No humus staining, however, was observed, and its absence may be an argument against the view here advanced. It is not a fatal objection, however, since its absence can be satisfactorily explained by the oxidation and leaching which the whole mass has undergone. This action is still going on, for the humus staining is being leached out of the underside of the present soil, as is indicated by its mottled appearance through a zone five or six inches thick.

4. The presence of at least one wind-eroded pebble in the sand lends some strength to this interpretation, although in the light of the studies of Davis and Woodworth on Cape Cod it cannot be regarded as conclusive.

The presence of scattered pebbles in the sand, too large to have been moved by the wind, may at first sight seem to be fatal to this view, but when all the facts are considered it is not so. That man was present is indicated by the artifacts found. The bank from which the pebbles may have been carried by human agencies is hardly more than a hundred feet away. Although the presence of the pebbles may, to some degree, weaken the argument it is not fatal to it.

My conclusions are, therefore, that the artifacts are probably found *in situ*. There is no positive evidence that the sand deposit is water-laid, and there are strong reasons, although perhaps not conclusive, that it is wind-blown. In the latter case it

may date from a period much later than the accumulation of the Trenton gravel. It seems most reasonable to suppose that it had accumulated after the river had cut its channel somewhat below the level of the terrace and formed a freely-cut bluff, from which the sand was derived. The localization of the sand along the present bluff and the reported greater abundance of the artifacts in the sand nearest the bluff supports this conclusion.

Substantially these same conclusions were reached by me at the time of my first visit to this locality, and my later observations served only to confirm them. In a letter to Professor Mercer, written about July 1st, I stated this view as to the origin of the sand, and the same conclusions were expressed to Professor Smock even earlier. Ever since my first visit to this locality I have been of the opinion that these deposits are probably æolian and that they certainly do not represent the closing stages of the Trenton gravel.

HENRY B. KÜMMEL.

LEWIS INSTITUTE, October 25, 1897.

SOCIETY FOR PLANT MORPHOLOGY AND PHYSIOLOGY.

THE first meeting of this Society was held in conjunction with the meeting of the American Society of Naturalists and the Affiliated Societies at Sage College, Cornell University, December 28 and 29, 1897. The following papers were presented:

1. *A Mycorrhiza in the Roots of the Liliaceous Genus Philesia*. DR. J. M. MACFARLANE, University of Pennsylvania.

A NEW case of this kind of Symbiosis was fully described and the conclusion reached that while the fungus might for many generations aid the host in the elaboration of protein compounds, ultimately though very gradually the fungus proved a destructive agent.